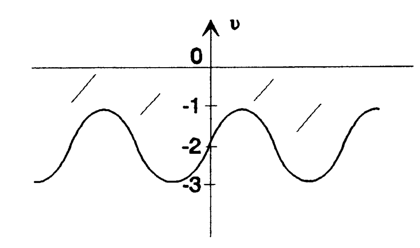
CHAPTER 25 (Odd)

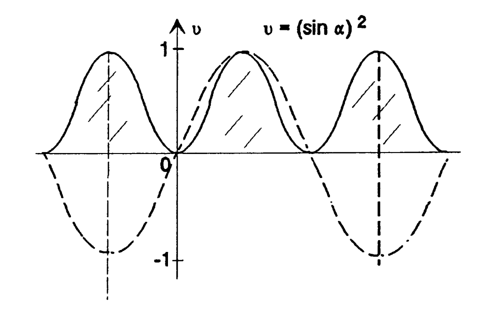
1.

I:	a.	no	b.	no	c.	yes	d.	no	e.	yes
II:	a.	yes	b.	yes	c.	yes	d.	yes	e.	no
III:	a.	yes	b.	yes	c.	no	d.	yes	e.	yes
IV:	a.	no	b.	no	c.	yes	d.	yes	e.	yes

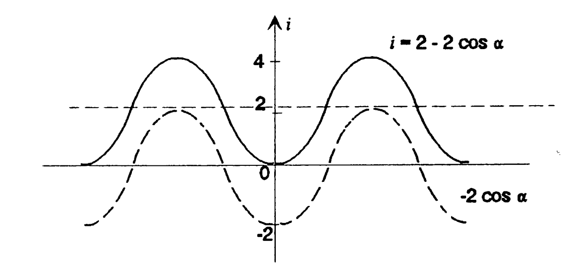
3. a. $v = -4 + 2 \sin \alpha$



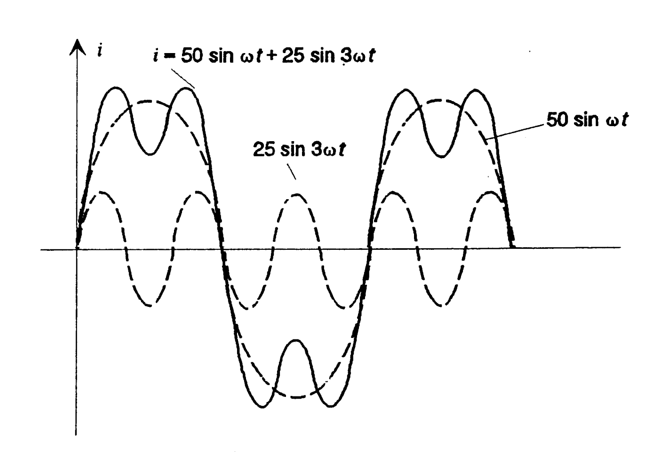
b. $v = (\sin \alpha)^2$



c. $i = 2 - 2 \cos \alpha$

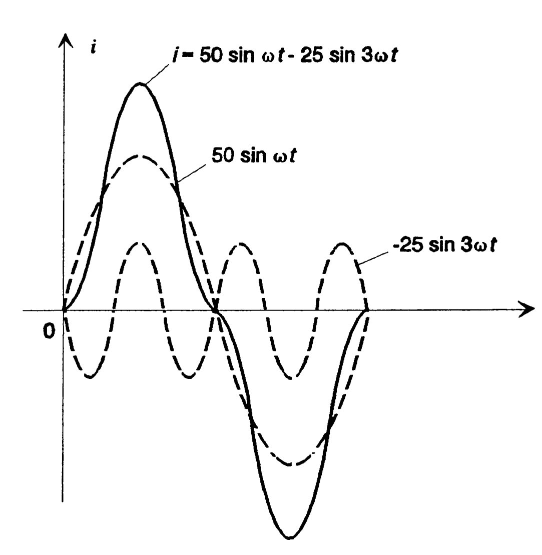


5. a.



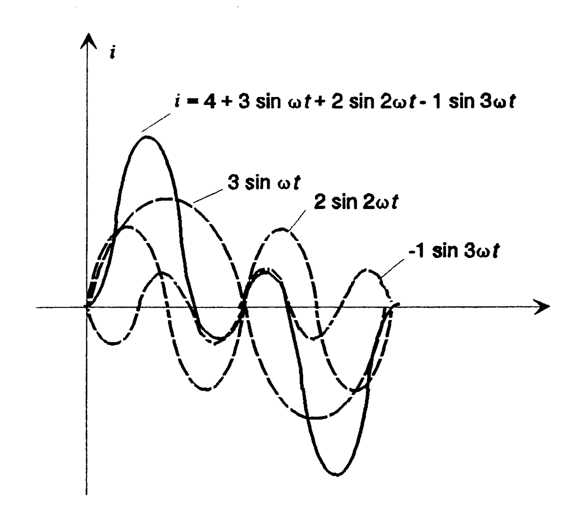
i
i = 50 sin ωt + 25 sin 3ωt
50 sin ωt
25 sin 3ωt

b.



i
i = 50 sin ωt - 25 sin 3ωt
50 sin ωt
-25 sin 3ωt
0

c.



i
i = 4 + 3 sin ωt + 2 sin 2ωt - 1 sin 3ωt
3 sin ωt
2 sin 2ωt
-1 sin 3ωt

7. a. $V_{eff} = \sqrt{\dfrac{(20\text{ V})^2 + (15\text{ V})^2 + (10\text{ V})^2}{2}} = \mathbf{19.04\ V}$

b. $I_{eff} = \sqrt{\dfrac{(6\text{ A})^2 + (2\text{ A})^2 + (1\text{ A})^2}{2}} = \mathbf{4.53\ A}$

9. $P = \dfrac{(20\text{ V})(6\text{A})}{2}\cos 20° + \dfrac{(15\text{ V})(2\text{ A})}{2}\cos 30° + \dfrac{(10\text{ V})(1\text{ A})}{2}\cos 60°$
$= 60(0.9397) + 15(0.866) + 5(0.5)$
$= \mathbf{71.872\ W}$

11. a. DC: $I_{DC} = \dfrac{24\text{ V}}{12\ \Omega} = 2\text{ A}$
$\omega = 400$ rad/s:
$\mathbf{Z} = 12\ \Omega + j(400\text{ rad/s})(0.02\text{ H}) = 12\ \Omega + j8\ \Omega = 14.422\ \Omega\ \angle 33.69°$
$\mathbf{I} = \dfrac{30\text{ V}\ \angle 0°}{14.422\ \Omega\ \angle 33.69°} = 2.08\text{ A}\ \angle -33.69°$ (peak values)
$\omega = 800$ rad/s:
$\mathbf{Z} = 12\ \Omega + j(800\text{ rad/s})(0.02\text{ H}) = 12\ \Omega + j16\ \Omega = 20\ \Omega\ \angle 53.13°$
$\mathbf{I} = \dfrac{10\text{ V}\ \angle 0°}{20\ \Omega\ \angle 53.13°} = 0.5\text{ A}\ \angle -53.13°$ (peak values)
$\boldsymbol{i = 2 + 2.08\sin(400t - 33.69°) + 0.5\sin(800t - 53.13°)}$

b. $I_{eff} = \sqrt{I_{DC}^2 + \dfrac{(2.08\text{ A})^2 + (0.5\text{ A}^2)}{2}} = \mathbf{2.508\ A}$

c. $v_R = iR = i(12\ \Omega)$
$\mathbf{= 24 + 24.96\sin(400t - 33.69°) + 6\sin(800t - 53.13°)}$

d. $V_{eff} = \sqrt{(24\text{ V})^2 + \dfrac{(24.96\text{ V})^2 + (6\text{ V})^2}{2}} = \mathbf{30.092\ V}$

e. DC: $V_L = 0$ V
$\omega = 400$ rad/s: $\mathbf{V}_L = (2.08\text{ A}\ \angle -33.69°)(8\ \Omega\ \angle 90°)$
$= 16.64\text{ V}\ \angle 56.31°$
$\omega = 800$ rad/s: $\mathbf{V}_L = (0.5\text{ A}\ \angle -53.13°)(16\ \Omega\ \angle 90°)$
$= 8\text{ V}\ \angle 36.87°$
$\boldsymbol{v_L = 0 + 16.64\sin(400t + 56.31°) + 8\sin(800t + 36.87°)}$

f. $V_{eff} = \sqrt{(0)^2 + \dfrac{(16.64\text{ V})^2 + (8\text{ V})^2}{2}} = \mathbf{13.055\ V}$

g. $P_T = I_{eff}^2 R = (2.508\text{ A})^2\ 12\ \Omega = \mathbf{75.481\ W}$

13. a. DC: $I = \mathbf{0\ A}$

$\omega = 400$ rad/s: $X_C = \dfrac{1}{\omega C} = \dfrac{1}{(400 \text{ rad/s})(125\ \mu\text{F})} = 20\ \Omega$

$\mathbf{Z} = 15\ \Omega - j20\ \Omega = 25\ \Omega\ \angle -53.13°$

$\mathbf{E} = (0.707)(30\text{ V})\ \angle 0° = 21.21\text{ V}\ \angle 0°$

$\mathbf{I} = \dfrac{\mathbf{E}}{\mathbf{Z}} = \dfrac{21.21\text{ V}\angle 0°}{25\ \Omega\ \angle -53.13°} = 0.848\text{ A}\ \angle 53.13°$

$i = 0 + (1.414)(0.848)\sin(400t + 53.13°)$

$i = \mathbf{1.2\ sin(400\mathit{t} + 53.13°)}$

b. $I_{\text{eff}} = \sqrt{\dfrac{(1.2\text{ A})^2}{2}} = \mathbf{0.848\ A}$ as above

c. DC: $V_R = 0$ V

$\omega = 400$ rad/s: $\mathbf{V}_R = (0.848\text{ A}\ \angle 53.13°)(15\ \Omega\ \angle 0°) = 12.72\text{ V}\ \angle 53.13°$

$v_R = 0 + (1.414)(12.72)\sin(400t + 53.13°)$

$v_R = \mathbf{18\ sin(400\mathit{t} + 53.13°)}$

d. $V_{R_{\text{eff}}} = \sqrt{\dfrac{(18\text{ V})^2}{2}} = \mathbf{12.73\ V}$

e. DC: $V_C = 18$ V

$\omega = 400$ rad/s: $\mathbf{V}_C = (0.848\text{ A}\ \angle 53.13°)(20\ \Omega\ \angle -90°)$

$= 16.96\text{ V}\ \angle -36.87°$

$v_C = 18 + (1.414)(16.96)\sin(400t - 36.87°)$

$v_C = \mathbf{18 + 23.98\ sin(400\mathit{t} - 36.87°)}$

f. $V_{C_{\text{eff}}} = \sqrt{(18\text{ V})^2 + \dfrac{(23.98\text{ V})^2}{2}} = \mathbf{24.73\ V}$

g. $P = I_{\text{eff}}^2 R = (0.848\text{ A})^2\ 15\ \Omega = \mathbf{10.79\ W}$

15. $i = 0.318I_m + 0.500\ I_m \sin \omega t - 0.212I_m \cos 2\omega t - 0.0424I_m \cos 4\omega t + \ldots\ (I_m = 10\text{ mA})$

$i = 3.18 \times 10^{-3} + 5 \times 10^{-3} \sin \omega t - 2.12 \times 10^{-3} \sin(2\omega t + 90°)$

$- 0.424 \times 10^{-3} \sin(4\omega t + 90°) + \ldots$

$i \cong 3.18 \times 10^{-3} + 5 \times 10^{-3} \sin \omega t - 2.12 \times 10^{-3} \sin(2\omega t + 90°)$

DC: $I_o = 0$ A, $V_o = 0$ V

$\omega = 377$ rad/s; $X_L = \omega L = (377 \text{ rad/s})(1.2\text{ mH}) = 0.452\ \Omega$

$X_C = \dfrac{1}{\omega C} = \dfrac{1}{(377\text{ rad/s})(200\ \mu\text{F})} = 13.26\ \Omega$

$\mathbf{Z}' = 200\ \Omega - j13.26\ \Omega = 200.44\ \Omega\ \angle -3.79°$

$\mathbf{I} = (0.707)(5 \times 10^{-3})\text{A}\ \angle 0° = 3.54\text{ mA}\ \angle 0°$

$\mathbf{I}_o = \dfrac{\mathbf{Z}_L\mathbf{I}}{\mathbf{Z}_L + \mathbf{Z}'} = \dfrac{(0.452\ \Omega\ \angle 90°)(3.54\text{ mA}\ \angle 0°)}{j0.452\ \Omega + 200\ \Omega - j13.26\ \Omega} = 7.98\ \mu\text{A}\ \angle 93.66°$

$\mathbf{V}_o = (7.98\ \mu\text{A}\ \angle 93.66°)(200\ \Omega\ \angle 0°) = 1.596\text{ mV}\ \angle 93.66°$

$\omega = 754$ rad/s: $X_L = \omega L = (754 \text{ rad/s})(1.2 \text{ mH}) = 0.905\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{(754 \text{ rad/s})(200\ \mu\text{F})} = 6.63\ \Omega$$

$$\mathbf{Z}' = 200\ \Omega - j6.63\ \Omega = 200.11\ \Omega\ \angle -1.9°$$

$$\mathbf{I} = (0.707)(2.12 \text{ mA})\ \angle 90° = 1.5 \text{ mA}\ \angle 90°$$

$$\mathbf{I}_o = \frac{\mathbf{Z}_L\mathbf{I}}{\mathbf{Z}_L + \mathbf{Z}'} = \frac{(0.905\ \Omega\ \angle 90°)(1.5 \text{ mA}\ \angle 90°)}{j0.905\ \Omega + 200\ \Omega - j6.63\ \Omega} = 6.8\ \mu\text{A}\ \angle 181.64°$$

$$\mathbf{V}_o = (6.8\ \mu\text{A}\ \angle 181.64°)(200\ \Omega\ \angle 0°) = 1.36 \text{ mA}\ \angle 181.64°$$

$$v_o = 0 + (1.414)(1.596 \times 10^{-3})\sin(377t + 93.66°) - (1.414)(1.360 \times 10^{-3})\sin(754t + 181.64°)$$

$$\boldsymbol{v_o = 2.257 \times 10^{-3} \sin(377t + 93.66°) + 1.923 \times 10^{-3} \sin(754t + 1.64°)}$$

17. $i_T = i_1 + i_2$

$= 10 + 30 \sin 20t - 0.5 \sin((40t + 90°)$
$+20 + 4 \sin(20t + 90°) + 0.5 \sin(40t + 30°)$

DC: $10 \text{ A} + 20 \text{ A} = 30 \text{ A}$

$\omega = 20$ rad/s: $30 \text{ A}\ \angle 0° + 4 \text{ A}\ \angle 90° = 30 \text{ A} + j4 \text{ A} = 30.27 \text{ A}\ \angle 7.59°$

$\omega = 40$ rad/s: $-0.5 \text{ A}\ \angle 90° + 0.5 \text{ A}\ \angle 30°$
$= -j0.5 \text{ A} + 0.433 \text{ A} + j0.25 \text{ A}$
$= 0.433 \text{ A} - j0.25 \text{ A} = 0.5 \text{ A}\ \angle -30°$

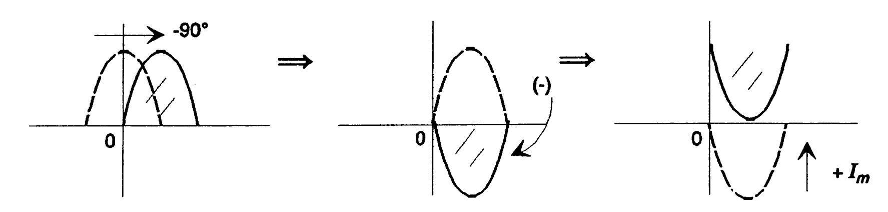
$$\boldsymbol{i_T = 30 + 30.27 \sin(20t + 7.59°) + 0.5 \sin(40t - 30°)}$$

CHAPTER 25 (Even)

2\. b. $$i = \frac{2I_m}{\pi}\left[1 + \frac{2}{3}\cos(2\omega t - 90°) - \frac{2}{15}\cos(4\omega t - 90°) + \frac{2}{35}\cos(6\omega t - 90°) + \ldots\right]$$

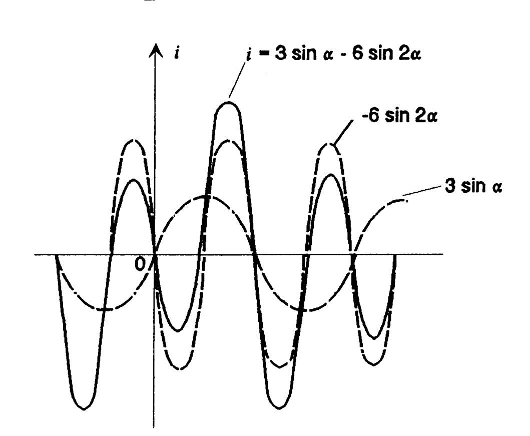
c. $$\frac{2I_m}{\pi} - \frac{I_m}{2} = \frac{2I_m}{\pi}\left[1 - \frac{\pi}{4}\right]$$
$$i = \frac{2I_m}{\pi}\left[1 - \frac{\pi}{4} + \frac{2}{3}\cos(2\omega t - 90°) - \frac{2}{15}\cos(4\omega t - 90°) + \frac{2}{35}\cos(6\omega t - 90°) + \ldots\right]$$

d.

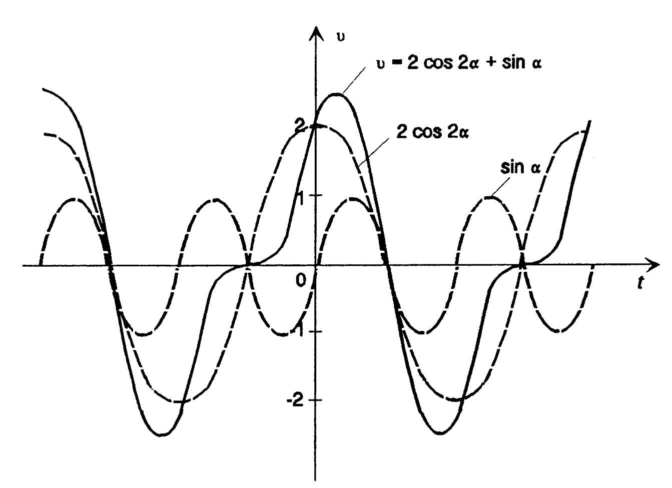


$$i = \frac{-2I_m}{\pi}\left[1 - \frac{\pi}{4} + \frac{2}{3}\cos(2\omega t - 90°) - \frac{2}{15}\cos(4\omega t - 90°) + \frac{2}{35}\cos(6\omega t - 90°) + \ldots\right]$$

4\. a.



b.



6. a. $V_{av} = \mathbf{100\ V}$

$$V_{eff} = \sqrt{(100\ V)^2 + \frac{(50\ V)^2 + (25\ V)^2}{2}} = \mathbf{107.53\ V}$$

b. $I_{av} = \mathbf{3\ A}$

$$I_{eff} = \sqrt{(3\ A)^2 + \frac{(2\ A)^2 + (0.8\ A)^2}{2}} = \mathbf{3.36\ A}$$

8. $P_T = V_0I_0 + V_1I_1 \cos\theta_1 + \ldots + V_nI_n \cos\theta_n$

$$= (100\ V)(3\ A) + \frac{(50\ V)(2\ A)}{2}\cos 53° + \frac{(25\ V)(0.8\ A)}{2}\cos 70°$$

$= 300 + (50)(0.6018) + (10)(0.3420)$

$= \mathbf{333.52\ W}$

10. a. DC: $E = 18\ V,\ I_o = \dfrac{E}{R} = \dfrac{18\ V}{12\ \Omega} = 1.5\ A$

$\omega = 400$ rad/s: $X_L = \omega L = (400\ \text{rad/s})(0.02\ H) = 8\ \Omega$

$\mathbf{Z} = 12\ \Omega + j8\ \Omega = 14.42\ \Omega\ \angle 33.69°$

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}} = \frac{30\ V/\sqrt{2}\ \angle 0°}{14.42\ \Omega\ \angle 33.69°} = \frac{2.08\ A}{\sqrt{2}}\ \angle -33.69°$$

$$i = 1.5 + \sqrt{2}\left[\frac{2.08}{\sqrt{2}}\right]\sin(400t - 33.69°)$$

$$\boldsymbol{i = 1.5 + 2.08\sin(400t - 33.69°)}$$

b. $$I_{eff} = \sqrt{(1.5\ A)^2 + \frac{(2.08\ A)^2}{2}} = \mathbf{2.101\ A}$$

c. DC: $v_R = E = 18\ V,\ \mathbf{V}_R = \left[\dfrac{2.08\ A}{\sqrt{2}}\ \angle -33.69°\right](12\ \Omega\ \angle 0°)$

$$= \frac{24.96\ V}{\sqrt{2}}\ \angle -33.69°$$

$$v_R = 18 + \sqrt{2}\left[\frac{24.96}{\sqrt{2}}\right]\sin(400t - 33.69°)$$

$$\boldsymbol{v_R = 18 + 24.96\sin(400t - 33.69°)}$$

d. $$V_{R_{eff}} = \sqrt{(18\ V)^2 + \frac{(24.96\ V)^2}{2}} = \mathbf{25.21\ V}$$

e. DC: $V_L = 0$ V

$$\omega = 400 \text{ rad/s: } \mathbf{V}_L = \left[\frac{2.08 \text{ A}}{\sqrt{2}} \angle -33.69°\right](8\ \Omega \angle 90°)$$

$$= \frac{16.64 \text{ A}}{\sqrt{2}} \angle 56.31°$$

$$v_L = \mathbf{0 + 16.64 \sin(400}t\mathbf{ + 56.31°)}$$

f. $$V_{L_{\text{eff}}} = \sqrt{0^2 + \frac{(16.64 \text{ V})^2}{2}} = \mathbf{11.766 \text{ V}}$$

g. $P = I^2_{\text{eff}}R = (2.101 \text{ A})^2\ 12\ \Omega = \mathbf{52.97 \text{ W}}$

12. a. DC: $I = -\dfrac{60 \text{ V}}{12\ \Omega} = -5$ A

$\omega = 300$ rad/s: $X_L = \omega L = (300 \text{ rad/s})(0.02 \text{ H}) = 6\ \Omega$

$$\mathbf{Z} = 12\ \Omega + j16\ \Omega = 13.42\ \Omega \angle 26.57°$$

$$\mathbf{E} = (0.707)(20 \text{ V}) \angle 0° = 14.14 \text{ V} \angle 0°$$

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}} = \frac{14.14 \text{ V} \angle 0°}{13.42\ \Omega \angle 26.57°} = 1.054 \text{ A} \angle -26.57°$$

$\omega = 600$ rad/s: $X_L = \omega L = (600 \text{ rad/s})(0.02 \text{ H}) = 12\ \Omega$

$$\mathbf{Z} = 12\ \Omega + j12\ \Omega = 16.97\ \Omega \angle 45°$$

$$\mathbf{E} = -(0.707)(10 \text{ V}) \angle 0° = -207 \text{ V} \angle 0°$$

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}} = -\frac{7.07 \text{ V} \angle 0°}{16.97\ \Omega \angle 45°} = -0.417 \text{ A} \angle -45°$$

$$i = -5 + (1.414)(1.054)\sin(300t - 26.57°) - (1.414)(0.417)\sin(600t - 45°)$$

$$i = \mathbf{-5 + 1.49 \sin(300}t\mathbf{ - 26.57°) - 0.59 \sin(600}t\mathbf{ - 45°)}$$

b. $$I_{\text{eff}} = \sqrt{(10 \text{ A})^2 + \frac{(1.49 \text{ A})^2 + (0.59 \text{ A})^2}{2}} = \mathbf{10.064 \text{ A}}$$

c. DC: $V = IR = (-5 \text{ A})(12\ \Omega) = -60$ V

$\omega = 300$ rad/s: $\mathbf{V}_R = (1.054 \text{ A} \angle -26.57°)(12\ \Omega \angle 0°)$
$= 12.648 \text{ V} \angle -26.57°$

$\omega = 600$ rad/s: $\mathbf{V}_R = (-0.417 \text{ A} \angle -45°)(12\ \Omega \angle 0°)$
$= -5 \text{ V} \angle -45°$

$$v_R = -60 + (1.414)(12.648)\sin(300t - 26.57°) - (1.414)(5)\sin(600t - 45°)$$

$$v_R = \mathbf{-60 + 17.884 \sin(300}t\mathbf{ - 26.57°) - 7.07 \sin(600}t\mathbf{ - 45°)}$$

d. $$V_{R_{\text{eff}}} = \sqrt{(60 \text{ V})^2 + \frac{(17.884 \text{ V})^2 + (7.07 \text{ V})^2}{2}} = \mathbf{61.52 \text{ V}}$$

e. DC: $V_L = 0$ V

$\omega = 300$ rad/s: $\mathbf{V}_L = (1.054 \text{ A} \angle -26.57°)(6\ \Omega \angle 90°) = 6.324 \text{ V} \angle 63.43°$

$\omega = 600$ rad/s: $\mathbf{V}_L = (-0.417 \text{ A} \angle -45°)(6\ \Omega \angle 90°) = -2.502 \text{ V} \angle 45°$

$v_L = 0 + (1.414)(6.324)\sin(300t + 63.43°) - (1.414)(2.502)\sin(600t + 45°)$

$v_L = \mathbf{8.942 \sin(300t + 63.43°) - 3.538 \sin(600t + 45°)}$

f. $$V_{L_{\text{eff}}} = \sqrt{\frac{(8.942 \text{ V})^2 + (3.538 \text{ V})^2}{2}} = \mathbf{6.8\ V}$$

g. $P = I_{\text{eff}}^2 R = (10.064 \text{ A})^2\ 12\ \Omega = \mathbf{1215.41\ W}$

14. a. $$e = \frac{200}{\pi} + \frac{400}{3\pi}\cos 2\omega t - \frac{400}{15\ \pi}\cos 4\omega t$$

$= 63.69 + 42.46 \sin(2\omega t + 90°) - 8.49 \sin(4\omega t + 90°)$

$\omega = 377$ rad/s:

$e = 63.69 + 42.46 \sin(754t + 90°) - 8.49 \sin(1508t + 90°)$

DC: $X_L = 0 \therefore V_L = 0$ V

$$\omega = 754 \text{ rad/s: } X_C = \frac{1}{\omega C} = \frac{1}{(754 \text{ rad/}s)(1\ \mu\text{F})} = 1330\ \Omega$$

$X_L = \omega L = (754 \text{ rad/s})(0.1 \text{ H}) = 75.4\ \Omega$

$\mathbf{Z}' = (1 \text{ k}\Omega \angle 0°) \| 75.4\ \Omega \angle 90° = 75.19\ \Omega \angle 85.69°$

$\mathbf{E} = (0.707)(42.46 \text{ V}) \angle 90° = 30.02 \text{ V} \angle 90°$

$$\mathbf{V}_o = \frac{\mathbf{Z}'(\mathbf{E})}{\mathbf{Z}' + \mathbf{Z}_C} = \frac{(75.19\ \Omega \angle 85.69°)(30.02 \text{ V} \angle 90°)}{75.19\ \Omega \angle 85.69° + 1330\ \Omega \angle -90°} = 1.799 \text{ V} \angle -94.57°$$

$$\omega = 1508 \text{ rad/s: } X_C = \frac{1}{\omega C} = \frac{1}{(1508 \text{ rad/s})(1\ \mu\text{F})} = 6631.13\ \Omega$$

$X_L = \omega L = (1508 \text{ rad/s})(0.1 \text{ H}) = 150.8\ \Omega$

$\mathbf{Z}' = (1 \text{ k}\Omega \angle 0°) \| 150.8\ \Omega \angle 90° = 149.12\ \Omega \angle 81.42°$

$\mathbf{E} = (0.707)(8.49 \text{ V}) \angle 90° = 6 \text{ V} \angle 90°$

$$\mathbf{V}_o = \frac{\mathbf{Z}'\mathbf{E}}{\mathbf{Z}' + \mathbf{Z}_C} = \frac{(149.12\ \Omega \angle 81.42°)(6 \text{ V} \angle 90°)}{149.12\ \Omega \angle 81.42° + 6631.13\ \Omega \angle -90°}$$

$= 1.73 \text{ V} \angle -101.1°$

$v_o = 0 + 1.414(1.799)\sin(754t - 94.57°) - 1.414(1.73)\sin(1508t - 101.1°)$

$v_o = \mathbf{2.54 \sin(754t - 94.57°) - 2.45 \sin(1508t - 101.1°)}$

b. $$V_{o_{\text{eff}}} = \sqrt{\frac{(2.54 \text{ V})^2 + (2.45 \text{ V})^2}{2}} = \mathbf{2.495\ V}$$

c. $$P = \frac{(V_{\text{eff}})^2}{R} = \frac{(2.495 \text{ V})^2}{1 \text{ k}\Omega} = \mathbf{6.225\ mW}$$

16. a. $60 + 70 \sin \omega t + 20 \sin(2\omega t + 90°) + 10 \sin(3\omega t + 60°)$
$+20 + 30 \sin \omega t - 20 \sin(2\omega t + 90°) + 5 \sin(3\omega t + 90°)$
DC: $60 + 20 = 80$
ω: $70 + 30 = 100 \Rightarrow 100 \sin \omega t$
2ω: 0
3ω: $10 \angle 60° + 5 \angle 90° = 5 + j8.66 + j5 = 5 + j13.66 = 14.55 \angle 69.9°$
Sum = **$80 + 100 \sin \omega t + 0 + 14.55 \sin(3\omega t + 69.9°)$**

b. $20 + 60 \sin \alpha + 10 \sin(2\alpha - 180°) + 5 \sin(3\alpha + 180°)$
$-5 + 10 \sin \alpha + \quad 0 \qquad - 4 \sin(3\alpha - 30°)$
DC: $20 - 5 = 15$
α: $60 + 10 = 70 \Rightarrow 70 \sin \alpha$
2α: $10 \sin(2\alpha - 180°)$
3α: $5 \angle 180° - 4 \angle -30° = -5 - [3.46 - j2] = -8.46 + j2$
$= 8.69 \angle 166.7°$
Sum = **$15 + 70 \sin \alpha + 10 \sin(2\alpha - 180°) + 8.69 \sin(3\alpha + 166.7°)$**

18. $e = v_1 + v_2$
$= \quad 20 - 200 \sin 600t + 100 \sin(1200t + 90°) + 75 \sin 1800t$
$-10 + 150 \sin(600t + 30°) \quad + 0 \quad + 50 \sin(1800t + 60°)$
DC: $20\text{ V} - 10\text{ V} = 10\text{ V}$
ω: 600 rad/s: $-200\text{ V} \angle 0° + 150\text{ V} \angle 30° = 102.66\text{ V} \angle 133.07°$
$\omega = 1200$ rad/s: $100 \sin(1200t + 90°)$
$\omega = 1800$ rad/s: $75\text{ V} \angle 0° + 50\text{ V} \angle 60° = 108.97\text{ V} \angle 23.41°$
$e = 10 + 102.66 \sin(600t + 133.07°) + 100 \sin(1200t + 90°) + 108.97 \sin(1800t + 23.41°)$